# SONORAN DESERT
## RAPID ECOREGIONAL ASSESSMENT

(Memorandum I-1-c)

**Prepared for:**
Department of Interior
Bureau of Land Management
Rapid Ecological Assessments

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# Executive Summary

The objective of this first stage of the Sonoran Desert Rapid Ecoregional Assessment (REA) was to identify the management questions, conservation elements, and change agents which will be used to characterize current conditions and future vulnerability of resources of conservation concern. The Dynamac team has reviewed the Statement of Work (SOW) and evaluated the feasibility and level of effort required to address each management question and conservation element. We have largely accepted all proposed conservation elements and management questions defined in the SOW. We did, however, identify some questions that are beyond the scope of the REA process and suggested revisions. Following guidance provided at the Pre-Work Meeting, through the BLM Point of Contact, and at the first Workshop, we have reworded some questions to provide the greatest opportunity to fully address the intended breadth and scope of this REA. In addition, we suggested and received approval for additional conservation elements, change agents, management questions, and landscape reporting units in an attempt to ensure that the output of this process will be readily incorporated into decision making and management plans at both the Regional and Field Office levels. Some of the management questions provided in the SOW were deleted as a result of Workshop comments and AMT review.

The REA framework was expected to follow a coarse-filter/fine-filter approach to conservation element selection and application. We selected Ecological Systems as *coarse-filters*. To serve the function of *fine-filters* in this REA, we received AMT direction to select a dominant plant species characteristic of each of the six largest geographical Ecological System coarse-filters.  In addition, we selected a set of *landscape species* based on an approach adapted from Coppolillo *et al*. (2004). The AMT had identified a list of core species in the SOW which were included among the candidate landscape species conservation elements. Core species which were not selected for inclusion in the suite of landscape species were defined as *desired species* conservation elements. In addition, we identified a suite of conservation elements representing sites and a suite of ecological functions and services of conservation concern as conservation elements. Major change agents were identified by the AMT in the SOW and accepted as important for the Sonoran Desert ecoregion REA, and a basic ecoregion conceptual model was constructed. One part of the REA process, we will assess the current status of each conservation element; identify specific current and near-term vulnerabilities to identified change agents. In addition, we will provide an assessment of potential impact or vulnerability of these conservation elements to climate change.

The selections of management questions, conservation elements, and change agents described in this memorandum represent the end product of several review processes. Following the Workshop and a helpful review of the Draft Memorandum I-1a by the AMT and peer reviewers, we have incorporated the recommended changes in Memorandum I-1-c. Several substantial changes were made, including the approaches to be used for identification of fine-filter species and landscape species. Dynamac reapplied the revised approaches to species selection to obtain the final suites of fine-filter and landscape species listed in this memorandum.

The memorandum contains lists the finalized management questions, coarse-filter conservation elements, fine-filter conservation elements, landscape species conservation elements, desired species conservation elements, and other conservation elements representing sites of conservation concern and ecological functions and services. In addition we list the major change agents affecting these conservation elements that will form the foundation of status and future condition forecasts for this REA. Some of these selections are tentative, and may be dropped at some point during the REA process for lack of data, appropriate approach, method, or tool, or because they may be better addressed within the context of a sub-assessment.

# 1. INTRODUCTION

The objective of this first memorandum is to identify the subjects that will form the basis of the Sonoran Desert Rapid Ecological Assessment (REA) in the months ahead. The purpose of the REA is to assess the current status of selected ecological resources at the ecoregional scale and to investigate how this status may change in the future across several time horizons. The knowledge gained from these assessments will provide the basis for future management planning across multiple spatial scales and jurisdictional boundaries and help direct future research in areas where knowledge gaps are identified. To that end, an important component of the REA process will be data compilation. We will use existing data, modeling, and GIS analyses in an attempt to provide answers to management questions.

Current status and future condition of the ecoregion's natural resources will be estimated by examining the relationships between a set of *conservation elements* and disturbance factors or *change agents*. The REA Task Order defines core conservation elements as biotic constituents (wildlife and plant species and assemblages) or abiotic factors (e.g., soils, regional values) of regional significance in major ecosystems and habitats across the level III ecoregion. This limited suite of conservation elements is designed to represent all renewable resources and values within the ecoregion; as such, the individual conservation elements may serve as surrogates for ecological condition across the ecoregion. Through the individual or interactive effects of change agents, the condition of conservation elements may depart from a model of a minimally-disturbed *reference condition* and thus from a state of ecological or biological integrity (Frey 1977, Karr and Dudley 1981). During the assessment process, we will estimate qualitatively how far from a theoretical reference condition each conservation element has deviated and by what means. This qualitative departure from reference condition will help to provide a snapshot of inferred ecological condition at the scale of both the various landscape reporting units and the ecoregion. Forecasts of how conservation element status is expected to change in the future will be approached in the same manner. The Dynamac team recommends that a more formal development of indicators of terrestrial ecological condition be supported as a future sub-assessment or separate research topic.

The AMT provided a list of core management questions to guide the assessment process. We evaluated each question to determine whether they could be answered feasibly with the inferred approach during the short timeframe of the REA. We identified a few management questions that, based on their language, appeared to require more time or resources to answer than were available for the REA based on our best professional judgment. In such cases, we either recommended the question for consideration as a sub-assessment, or suggested a rewording for AMT consideration to reflect an approach that was within the scope of the REA. In some instances, we identified additional management questions for consideration by the AMT. Following the first Workshop, the AMT reviewed and finalized any suggested changes to management questions.

We also conducted a review of the selection of conservation elements. Conservation elements included Ecological Systems (vegetation communities) as coarse-filters, a selection of characteristic plant species representative of the primary Ecological Systems for use as fine-filters, sensitive species as a richness function, landscape species, and a set of desired species identified by the AMT. In addition, a wide range of terrestrial and aquatic sites and ecological services and functions (such as soil stability) were considered for inclusion as conservation elements. We identified all Ecological Systems present within the external boundary of the Level III ecoregion for use as coarse-filters in this REA. We defined our Ecological Systems based on the vegetation assemblage classes used in the SWReGAP project (Prior-Magee et al. 2007).

The initial selection of species created considerable debate at the first Workshop. This debate centered on the selection process itself, the rationale for inclusion of vulnerable species, and the mixing of vulnerable species and species managed for game. The Dynamac team had assumed that we were to include all of those species identified as core species by the AMT. We initially developed a dichotomous key approach for selecting additional species based on the constraints identified in the SOW. Following the Workshop, we were asked to rerun the *fine-filter species* selection process following the approach outlined in Unnasch *et al*. (2008); and Parrish *et al*. (2003). Subsequently, we received AMT direction to select a dominant plant species from the principle Ecological Systems to function as fine-filters for the purpose of this REA. In addition, we were asked to follow the general approach developed by Coppolillo *et al*. (2004) for selection of *landscape species*. Landscape species play an important functional role in the ecosystem; they are characterized by their utilization of a wide range of habitats, large home ranges covering a large proportion of the study area, vulnerability to anthropogenic impacts, and high socio-economic value.

Coppolillo *et al*. (2004) acknowledged that their approach, while useful for guiding conservation planning efforts, had not been, and probably could not be verified. We used the basic structure of the approach, while redefining some of the component scoring procedures. We then selected a set of 25–30 species from the State Wildlife Action Plan lists and the SWReGAP list, as well as the core species identified in the SOW by the AMT, and proceeded to score each. We used this approach to select a suite of landscape species; those species identified by the AMT that failed to make it on the list as landscape species were reserved as *desired species* for separate assessments.

Assessment of the status of conservation elements must be conducted with reference to both natural and anthropogenic disturbance factors. The concept of reference condition includes natural disturbance dynamics and the full range of potential natural successional trajectories and states. Deviation from the range of natural states characterizing reference condition is due to direct or indirect disturbances of anthropogenic origin (Hughes et al. 1986, Hughes 1995). These disturbances represent the change agents of interest in the REA process. Many effects of change agents are obvious, representing changes in land use during development: agriculture, resource extraction, such as logging and mining, and traditional and renewable energy development. Other effects are more diffuse, such as the effects of livestock grazing and the intentional or unintentional introduction of invasive species. Fire, while it is a natural disturbance agent, often deviates from its characteristic regime, through fire suppression, increased ignition frequencies, and changes in characteristic fuels and fuel loads. In this way fire, at least in the deviation from what would be expected, can be considered as a form of anthropogenic change agent. We accepted the change agents identified by the AMT as clearly important to ecological resources at the ecoregional scale and we suggested an additional, unrelated change agent for AMT consideration.

In the following sections, we will review the finalized selections of management questions, conservation elements, and agents of change that form the focus of this Rapid Ecoregional Assessment.

# 2. REA Study Area and Landscape Reporting Units

## 2.1 Study Area

This REA will be conducted within the boundaries of the Sonoran Desert ecoregion (Figure 1) and a buffer area consisting of 5$^{th}$ level hydrologic units. The purpose of the buffer is to help ensure agreement between mapped layers generated for REAs in neighboring regions and to avoid problems associated with “edge effects” during GIS analyses.

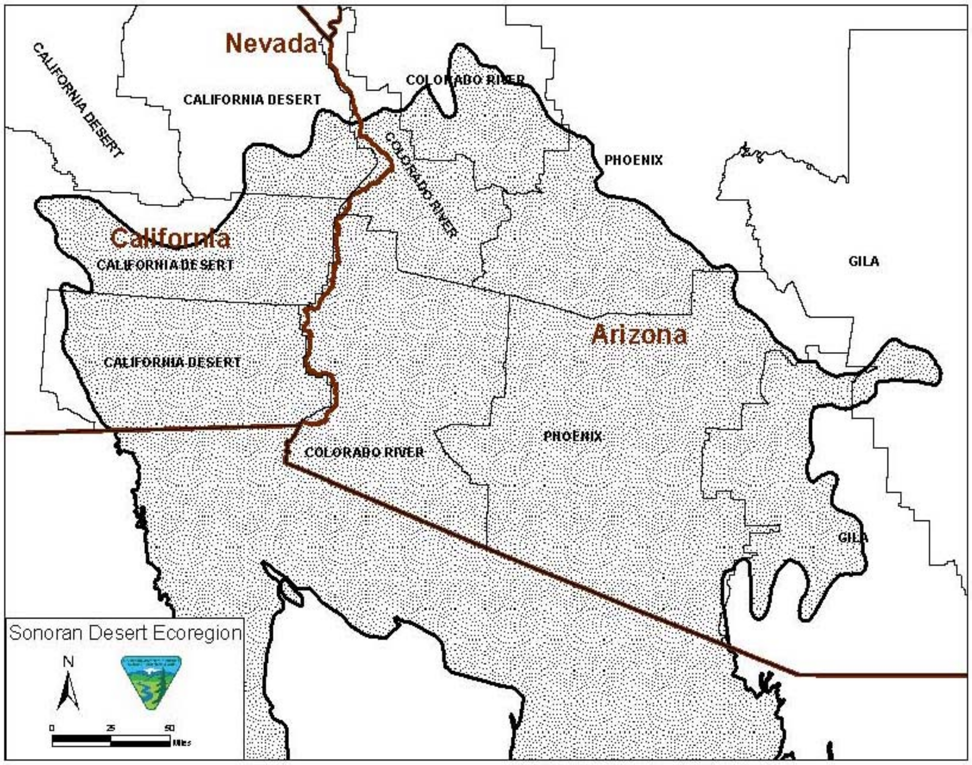


**Figure 1. The general extent of the Sonoran Desert Ecoregion (shaded).**

## 2.2 Landscape Reporting Units

Assessment data will be summarized in landscape reporting units. These are predefined areas general enough to provide useful information regarding resource status and coarse enough to avoid mapping at an inappropriately fine grain. The resolution of the data will vary. In GIS analyses, it is important to recognize that the information content is only as good as the input data with the coarsest resolution. Summarizing information at a coarse resolution is one means to overcome this limitation, while at the same time providing an ecoregional perspective on the condition of resources of conservation significance.

Two landscape reporting units were identified in the SOW: 30m pixels for raster data and the 5$^{th}$ level hydrologic unit. The Dynamac team accepted both and suggested two others to the AMT. We recommended the inclusion of aquifer boundaries as landscape reporting units. Our rationale for this was that many of the aquatic resource management questions focus on potential changes in current and future groundwater extraction on conservation elements dependent on those resources. We felt that summaries of species richness, or richness of species of conservation concern, by aquifer would be helpful in future planning for water extraction needs. <u>This reporting unit was also accepted by the group and the AMT</u>. Finally, we suggested including a landscape reporting unit that represented the resolution of the 15 km climate data that will be used in the REA. The rationale for using this resolution is that in any geospatial analyses the information content is limited by the coarsest resolution of the data, in this case, the climate data. <u>The 15 km reporting unit was accepted by both the group and the AMT for use in appropriate situations.</u>

## 3. Basic Ecoregion Conceptual Model

### 3.1 Introduction

The purpose of the REA is to assess the current and future condition of resources of conservation concern. The reference condition of these resources or conservation elements is dependent on direct and indirect effects associated with natural disturbances or change agents, such as cycles of fire, drought, pests, and pathogens. The range of conditions and the dynamics associated with the condition of these resources prior to European settlement constitutes the operational definition of a theoretical state of ecological integrity. Our actions, from direct conversion of natural vegetation to agriculture or parking lots, to effects of pollutants, spread of invasive species, alteration of fire regimes, resource use, off-road vehicle use, and stresses associated simply with proximity to human activities all impinge upon the condition of these resources. To visualize the tangled web of relationships and the mechanisms of change, conceptual models can be helpful. They are also helpful in defining conceptual relationships between conservation elements, threats, and associated change agents that can form the basis for selection of management questions (Figure 2).

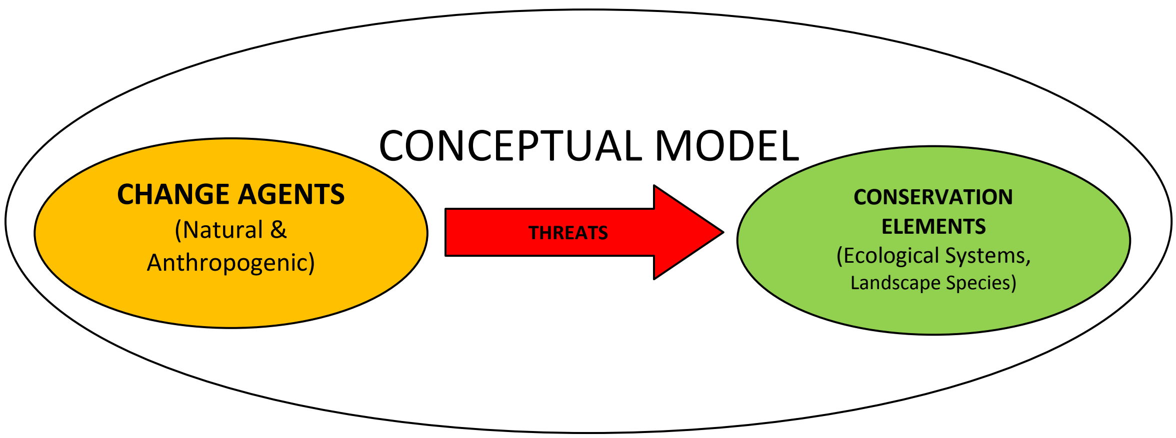


**Figure 2. General relationship between change agents, threats or stressors, and the conservation elements in the ecoregion.**

### 3.2 Description of the Basic Ecoregional Conceptual Model for the Sonoran Desert

In the list of Environmental Protection Agency level III ecoregions (Omernik 1995) the Sonoran ecoregion is called the Sonoran Basin and Range rather than the Sonoran Desert, because the region's desert basins and uplands are punctuated by scattered low mountain ranges. Broadly speaking, the Sonoran Desert ecoregion is divided into a lower, drier western section, that includes the Salton Sea basin and the lower Colorado Desert, and a somewhat higher eastern section that is also relatively more moist (by desert standards), as it experiences the summer monsoonal rains. Winter rainfall has the opposite pattern, decreasing from west to east. Annually across the region, precipitation ranges from 3 to 10 inches; in the desert a difference of one or two inches of precipitation can make a large difference in the vegetative cover. The vegetation of the lower elevation western Sonoran is dominated by creosote bush and white bursage, but in the eastern upland, somewhat higher precipitation amounts support a more diverse vegetation community with palo verde, acacia, ocotillo, and a variety of cacti.

In the basic ecoregional conceptual model (Figure 3), boxes represent conservation elements, ovals represent classes of change agents, and arrows represent the direct and indirect effects (threats or stresses) on the ecosystem components, including conservation elements. No distinction is made in this simplified model to distinguish between direct or indirect effects or their magnitude. The present model also lacks spatial or temporal components that will be developed later in more detailed models.

Regional climatic conditions represent the dominant natural change agent in the basic ecoregion conceptual model (Figure 3). Secondary natural regional change agents include cyclical drought and the natural fire regime (a minor factor in presettlement times and included here mainly as a place holder to help illustrate increasing incidence of fire in more recent times). Natural change agent classes are depicted as orange ovals in the conceptual model. Across the ecoregion, variability in geology, physiography, elevation, aspect, ground and surface water availability, and soil (texture, depth, and water-holding capacity) is reflected in patterns of vegetative cover. Black arrows drawn between the boxes in the model depict the major interactions between natural abiotic and biotic components.

Four representative natural vegetation (coarse filter or habitat) classes are centrally located in the ecoregion conceptual model. The boxes for vegetation classes are depicted in the conceptual model according to elevational and moisture differences; they represent the coarse filter conservation element classes covering more than 1 or 2% of the ecoregion area (although every vegetation class is included in the coarse-filter selection of conservation elements). The **Upper Bajada and Low Mountain Tree/Shrub** category is drawn from the Forest and Woodland and upper Shrub/Scrub coarse filter vegetation classes—that is, the small patches of chaparral, broadleaf evergreen, or conifer species in foothill ecotonal areas or at the tops of Sonoran mountain ranges. The box marked **Diverse Desert Shrub** represents the upland Sonoran Paloverde-Mixed Cacti Desert Scrub (including Saguaro communities) and the Mojave Mid-Elevation Mixed Desert Scrub (including the Joshua tree anomaly). The **Lowland Shrub** box corresponds to the Sonora-Mojave Creosotebush-White Bursage Desert Scrub, Sonora-Mojave Mixed Salt Desert Scrub, and the Sonoran Mid-Elevation Desert Scrub classes common to the lower elevation Colorado desert in the Western Sonoran. The box marked **Riparian and Wash Communities** represents the coarse filter vegetation classes Woody Wetland and Riparian Communities and Emergent Herbaceous Wetlands. Also included in this class are the intermittent and ephemeral wash communities: the North American Warm Desert Riparian Mesquite Bosque and the North American Warm Desert Wash. Wildlife occurrence and abundance is dependent on interactions with all these abiotic factors (most importantly in the Sonoran ecoregion, temperature regulation and water availability) and the vegetation classes (or major habitats).

The overlay of human activities, expressed as anthropogenic change agents and change agent subclasses, are shown in yellow ovals on the conceptual model (Figure 3). The major change agents include wildland fire, invasive species, land and resource use, and climate change. Land and resource use covers major human activities such as urban and industrial development, surface and groundwater extraction, recreation, agriculture, and grazing. The red arrows mark the interactions of human activities with other model components. For example, the orange and yellow concentric ovals surrounding the change agent *fire* symbolizes the change in fire regime in the Sonoran desert in recent decades; historically, fire was not a major influence in the Sonoran desert, but the introduction and use of annuals such as buffel grass (*Pennisetum ciliare*) has been one factor implicated in the increasing incidence of fire. This is noted in the conceptual model by a red arrow extending from *invasives* to *fire.*

The basic ecoregion conceptual model serves as the source for more detailed conceptual sub-models that will accompany subsequent modeling and assessments. For example, the sub-model for Colorado Desert lowland shrub will show additional detail in interactions between human influences such as energy development, agricultural conversion, grazing, and OHV recreation, and the effects on the vegetation community and surrounding landscape from surface and groundwater withdrawals, water transfers, irrigation, changes in fire regime, introduction of non-native annuals, soil disturbance, and increased soil and wind erosion.

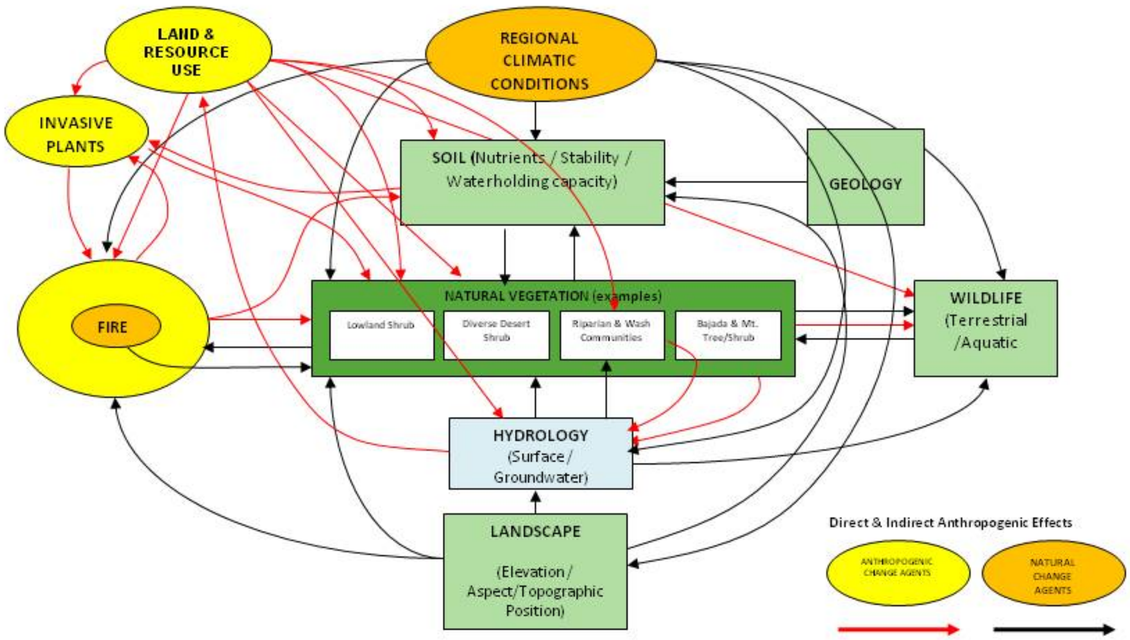


**Figure 3. Generalized ecoregion conceptual model for the Sonoran Desert Ecoregion, with both natural (orange oval) and anthropogenic (yellow oval) change agents shown and associated direct and indirect threats (red arrows represent anthropogenic threats) on ecosystem components.**

## 4. Management Questions

### 4.1 Introduction

The AMT defined a set of preliminary management questions in the SOW for this REA. These questions were broad in scope. Part of the challenge of this first REA was to gauge the time and resource requirements needed to address the full complement of management questions in a manner that would have utility for BLM for future planning purposes. Management questions fell into two general categories. The first category included what/where questions that could be answered with simple data compilation and summaries. In many instances, we expect the questions may have already been answered in earlier studies. A second category of management questions suggested the need for considerable analytical processing as well as data compilation.

## 4.2 Review and Feasibility Assessment of Management Questions

We examined each question and determined the type of data required and the probable approaches and methods that could be used. Management questions were then rated based on these approaches as routine GIS summaries, involved analyses, complex/costly/time consuming analyses, or basic research–beyond scope. It was our intent to address each management question in some manner, if feasible, particularly if the nature of the output would have some utility for BLM and agency partners.

In preparing the draft version of this Memorandum, we highlighted management questions that appeared to require an effort beyond the scope of the REA process. We received helpful guidance from BLM regarding the expected level of effort and the nature of some types of analyses. We revised our time estimates and then prepared suggested revisions of certain management questions to reflect this guidance. These suggestions were reviewed at the first Workshop, and, following AMT review and additions, many have been accepted. In some cases we identified a management question that we felt could not be answered, for example, a question related to predicting changes in water temperature in streams across the landscape under a future climate change scenario. It was our opinion that the output would lack both the accuracy and precision needed to infer potential changes in thermal habitat for aquatic species. We indicated that the National Hydrography Dataset stream flow status attribute currently has a high rate of error in the arid ecoregions. We related that in a recent stream survey project conducted by the EPA (Stoddard et al. 2005), many streams identified as perennial were in fact not perennial (Figure 4). This level of uncertainty, we argued, made estimation of future flow and temperature changes unreliable. The reviewers agreed, and the management question was deleted.

Elsewhere, we suggested new management questions for AMT consideration. These were presented in the draft version of this Memorandum and again at the first Workshop. Following review by Workshop participants, USGS peer review, and AMT review, we received a finalized set of management questions that are presented in the following section.

## 4.3 Approved and Finalized Management Questions

### 4.3.1 Related to Terrestrial Ecological Features, Functions, and Services as Conservation Elements

***QUE (Coarse-Filter Ecological Systems): Where are these intact vegetative communities located?***
**Resolution:** The question was accepted by the AMT and the group without discussion.

***QUE (Coarse-Filter Ecological Systems): What/where is the potential for future change to dominant species associated with principle communities?***
**Resolution:** There appeared to be group consensus to accept the question with the suggested change in approach.

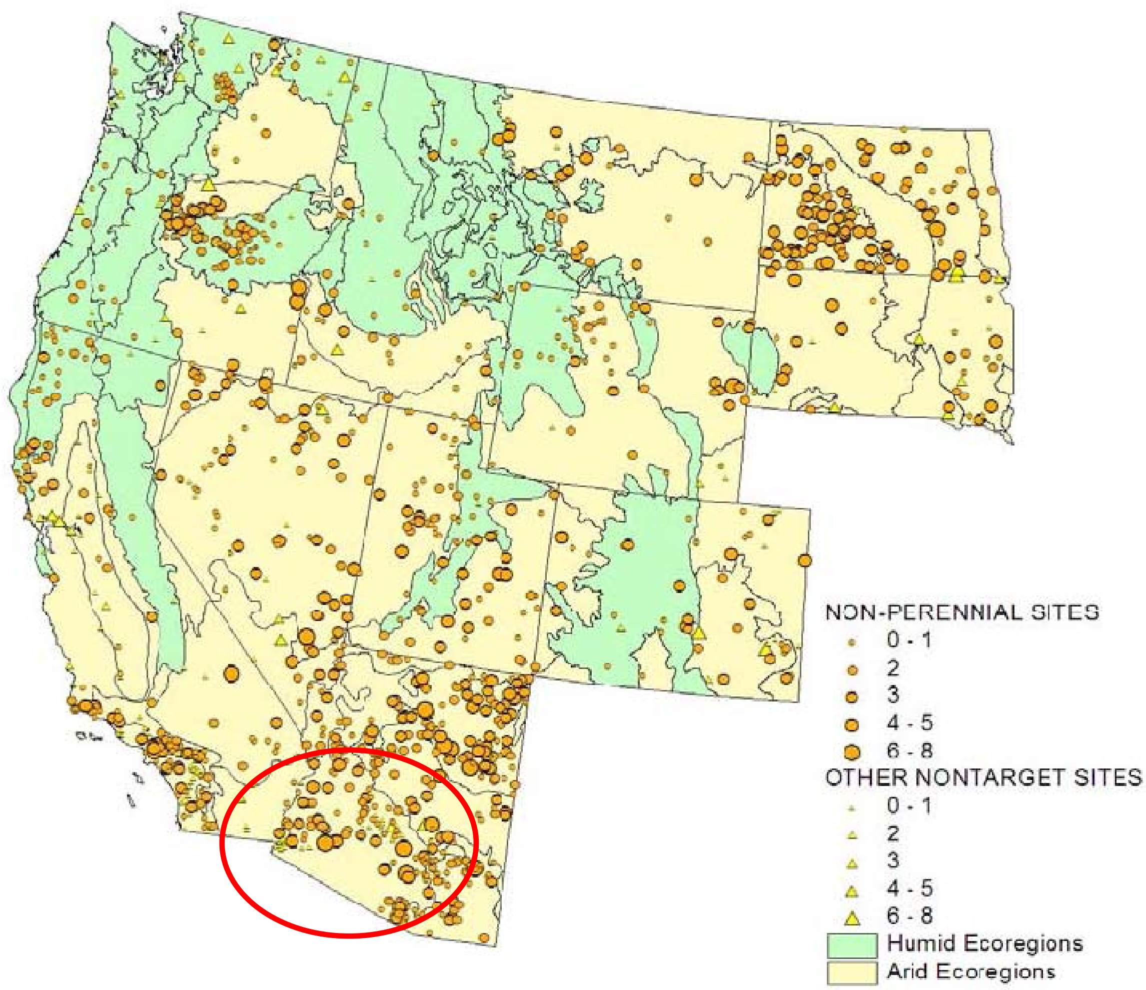


**Figure 4. Streams identified as perennial which were non-perennial in the EMAP-West stream survey project (from Stoddard *et al*. 2005).**

### 4.3.2 Related to Species as Conservation Elements

***What is the current distribution of occupied habitat, including seasonal habitat, and movement corridors?***
The REA effort will rely on the results of the Western Governors' Association Southwestern States Wildlife Corridor Initiative to provide the data necessary to answer this management question.
**Resolution:** The question was accepted by the AMT and the group.

***What areas have been surveyed and what areas have not been surveyed (i.e., data gap locations)?***
Dynamac suggested a revision to the question: What areas are known to have been surveyed and what areas are not known to have been surveyed?
**Resolution**: The revised wording was accepted by the group at the workshop.

***Where are change agents affecting these habitat and movement corridors?***
**Resolution**: This question was accepted as written.

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***Where are habitats that may be limiting species sustainability?***
**Resolution:** The AMT and the workshop participants accepted this management question without discussion.

***Where are species populations at risk?***
**Resolution:** The AMT and the workshop participants accepted this management question without discussion.

***Where are potential habitat restoration areas?***
BLM is interested in taking a broad view of this question, looking at larger areas for restoration (rather than at the allotment level), that have a precipitation, elevation, and soil character that suggest an opportunity for successful restoration.
**Resolution**: The AMT and the workshop participants accepted the broader view of this question.

***Where are potential areas to restore connectivity?***
The REA effort will rely on the results of the Western Governors' Association Southwestern States Wildlife Corridor Initiative to provide the data necessary to answer this management question.
**Resolution:** The question was accepted by the AMT and the group.

***What/where is the potential for future change to this species?***
Dynamac proposed breaking this question into several time frames and change agent sources and suggested that the question be revised to read: What/where is the potential for future change to this species in the near-term horizon 2020 (development) and a long-term change horizon 2060 (climate change)?
**Resolution:** The revised wording was accepted by the group.

### 4.3.3 Related to Terrestrial Sites as Conservation Elements

***QUE (Terrestrial Sites as Conservation Elements): What is the location/distribution of these sites?***
These two groups of sites will simply be merged into a single vector data layer each, identified at a minimum by site identification and primary vegetation community type. This compiled layer will then be used as the basis for potential change analysis management questions. We suggest that we also treat the compiled GAP biodiversity data in the same manner.
**Resolution:** This question was accepted by the group without discussion.

***QUE (Terrestrial Sites as Conservation Elements): What/where is the potential for future change to these high-biodiversity sites?*** Dynamac suggested changing the wording to: What/where is the potential for future change to these high-diversity sites in the near-term horizon, 2020 (development) and a long-term change horizon, 2060 (climate change)?
**Resolution**: There was no objection to changing the question or the near-term and long-term aspects of the question.

***QUE (Viewsheds as Conservation Elements): Where are the viewsheds adjacent to <u>designated</u> scenic areas?*** **Resolution**: The question was accepted as revised by the AMT.

***QUE (Viewsheds as Conservation Elements): Where are the viewsheds most vulnerable to change agents?***
**Resolution**: The wording of this question was accepted as written.

### 4.3.4 Related to Aquatic Ecological Features, Functions, and Services Conservation Elements

***QUE (Aquatic Features, Functions & Services): Where are these aquatic areas?*** If the data is available, we suggest inclusion of livestock watering tanks to this list of surface water availability, as these water sources. Identification of springs and seeps is problematic. We will not be able to identify all springs. Dynamac suggested rewording: Where are the surface water bodies and livestock or wildlife watering tanks?
**Resolution**: The group agreed to adding artificial watering areas.

***QUE (Aquatic Features, Functions & Services): What is the persistence of the flow (e.g., perennial, ephemeral) of these systems?*** Hydrologic modeling of flow is beyond the scope of an REA, so the Dynamac Team will suggest that we answer this question in a more qualitative manner. We will identify those bodies of water which are currently characterized by flow status in the NHD data for a first level summary, recognizing that the accuracy will be low, based on our experiences sampling in the arid west. Dynamac will use estimates of NHD flow error from the EMAP-West probabilistic sampling study to help quantify this level of uncertainty by Strahler order.
**Resolution:** This question was accepted by the group without discussion.

***QUE (Aquatic Features, Functions & Services): Where are the aquifers and their recharge areas?***
**Resolution:** The question was accepted without discussion.

***QUE (Aquatic Features, Functions & Services): What is their surface water/groundwater connectivity?*** Dynamac suggested rewording the question to read: Which surface waters are likely dependent on groundwater to maintain their ecological condition?
**Resolution**: The group accepted Dynamac's suggested changes to this question.

***QUE (Aquatic Features, Functions & Services): What/where is the potential for future change in extent and flows from change agents?*** Dynamac suggested rewording the questions to read: Where and in what direction are surface water flows likely to change at the scale of the 5$^{th}$ Level HU, both annually and seasonally? The AMT suggested putting the question in the same time frame (2020 and 2060) as with other future change questions.
**Resolution**: There appeared to be group consensus to change the question as suggested by Dynamac and the AMT.

***QUE (Aquatic Features, Functions & Services): What is the condition of these various aquatic systems defined by PFC?***
**Resolution:** This question was accepted as written.

***QUE (Aquatic Features, Functions & Services): Where are the degraded aquatic systems (e.g., water quality)?*** **Resolution:** This question was accepted as written.

### 4.3.5 Related to Aquatic Sites of Regional Importance as Conservation Elements

***QUE (Aquatic Sites): What is the location/distribution of these sites?*** These resources will simply be merged into several vector data layers identifying surface water features. The attribute files will contain required information to characterize surface water type, and where feasible, quality. These compiled layers will then be used as the basis for potential change analysis management questions.
**Resolution:** The question was accepted without discussion.

***QUE (Aquatic Sites): What/where is the potential for future change to these high-biodiversity sites?***
As discussed earlier, areas of potential change from non-climate related agents will be mapped over a time frame agreed upon with the AMT. We suggest disturbances planned by 2020 as a time horizon. We will identify the catchments associated with each site, and identify those catchments with planned change, and score them in a qualitative fashion, from no planned disturbance, to major planned disturbance. In addition, we will identify probable changes in these catchments under the 2060 climate change scenario. We will distinguish potential impacts associated with development and other anthropogenic disturbances, including potential spread of invasive species, and changes associated with climate. We will then merge the two sets of data to help identify those sites which are likely to experience the most change. Dynamac suggested rewording the question to reflect the near-term and long-term time horizons as suggested in future change questions above.
**Resolution**: The revised question was accepted by the group.

### 4.3.6 Related to Change Agents

***QUE (Change Agent – Fire): Where are the areas that have been changed from wildfire?***
**Resolution:** Accepted as written.

***QUE (Change Agent – Fire): Where are the areas with potential to change from wildfire?***
In addition, we propose that we generate a fire return interval map from the LANDFIRE data, superimposing recent burns and mapped invasive annual grasses, since they will shorten the fire return interval suggested in the LANDFIRE classifications. We will then reclassify these data to reflect an annualized probability of fire, an indicator of fire potential.
**Resolution:** The question was accepted by the group. There was some discussion to reflect the view: Where is the risk of fire higher? But the wording of the question was not changed.

***QUE (Change Agent – Fire): Where are fire-adapted communities?***
**Resolution**: The question was accepted as revised by the AMT.

***QUE (Change Agent – Invasive Species): Where are areas dominated by this invasive species?***
**Resolution**: There was general agreement to accept the wording of the question.

***QUE (Change Agent – Invasive Species): Where are areas with restoration potential?***
**Resolution**: There was general agreement to accept the wording of the question.

***QUE (Change Agent – Invasive Species): Where are the areas of potential future encroachment from this invasive species?***
**Resolution**: There was general agreement to accept the wording of the question.

***QUE (Change Agent – Urban & Industrial Development): Where are current locations of these development types?***
**Resolution:** This question was accepted as written.

***QUE (Change Agent – Urban & Industrial Development): Where are areas of planned development (e.g., plans of operation, governmental planning)?***
**Resolution:** This question was accepted as written.

***QUE (Change Agent – Urban & Industrial Development): Where are areas of potential development (e.g., under lease), including sites and transmission corridors?***
**Resolution:** This question was accepted as written.

***QUE (Change Agent – Groundwater Extraction & Transport): Where are surface water areas of potential to change (flow reduction) from groundwater extraction?***
**Resolution**: The question was accepted as revised by the AMT.

***QUE (Change Agent – Groundwater Extraction & Transport): Where are the areas of high and low groundwater potential in relation to supporting solar power, sustaining species, etc.?*** The AMT suggested wording the question: Where are areas of high and low groundwater potential?
**Resolution**: The group agreed to change the wording of the question as suggested.

***QUE (Change Agent – Groundwater Extraction & Transport): Where are the areas showing effects from existing groundwater extraction?*** The ability to answer this question is dependent upon data availability. There are declines in many areas, (such as Phoenix), so we expect the information to be readily available. We will identify the specific aquifers associated with major changes water availability.
**Resolution:** The group agreed to this question without discussion.

***QUE (Change Agent – Groundwater Extraction & Transport): Where are artificial water bodies including evaporation ponds, etc.?***
**Resolution:** The AMT suggested keeping the wording of this question (including evaporation ponds) when it was noted that evaporation ponds are defined as mining effluent ponds that can poison wildlife.

***QUE (Change Agent – Resource Use): Where are high-use recreation sites, developments, infrastructure or areas of intensive recreation use located (including boating)?***
**Resolution:** The question was accepted by the workshop group as written.

***QUE (Change Agent – Resource Use): Where are areas of concentrated recreation travel located (OHV and other travel)?***
**Resolution:** The question was accepted by the workshop group as written.

***QUE (Change Agent – Resource Use): Where are permitted areas of intensive recreation use (permit issued)?***
**Resolution:** The question was accepted by the workshop group as written.

***QUE (Change Agent – Land Sales, Exchanges and Acquisitions): What are planned areas for disposal that may cause change of Federal ownership?*** We envision this as a rather routine data compilation exercise from various data sources.
**Resolution:** This question was accepted as written.

***QUE (Change Agent – Air Pollution): Where are the designated non-attainment areas and Class I PSD areas?*** We will map the Class 1Prevention of Significant Deterioration (PSD) areas in the

ecoregion. Class I areas are areas of special national or regional natural, scenic, recreational, or historic value and determined to require special protection. We will also map out areas of non-attainment obtained from the EPA (http://www.epa.gov/air/data/nonat.html).
**Resolution:** The wording of the question was accepted by the group.

***QUE (Change Agent – Livestock Grazing):***
**Resolution:** The grazing issue will require further discussion by the AMT and the Washington office; they will specify how it should be addressed. The AMT is evaluating questions referring to grazing as a change agent.

***QUE (Change Agent – Climate Change & Terrestrial Resources): Where/how will the distribution of native plant species and invasive species change from climate change?***
**Resolution:** Change the word communities to species and accept as written.

***QUE (Change Agent – Climate Change & Terrestrial Resources): Where are areas of potential species (conservation elements) distribution change?*** We suggest modeling changes in ptoential species distribution between 2010 and 2060 time periods to provide an indication of areas of range contraction, stability, and range expansion.
**Resolution:** A revised wording of the question was accepted.

***QUE (Change Agent – Climate Change & Aquatic Resources): Where are aquatic/riparian areas with potential to change from climate change?***
**Resolution:** This question was accepted as written.

***QUE (Change Agent – Climate Change & Aquatic Resources): Where are areas of potential flow change?*** This question is closely related to the former, and the output may suffice to address this question. To capture a qualitative picture of changes in relative potential flashiness of the systems, we would suggest overlaying the maximum monthly precipitation ranges of 2010 and 2060. Areas with greater maximum monthly ranges in 2060 than in 2010 will be interpreted as areas of increased flashiness. Dynamac suggested revising the question to read: Where are areas of potential *surface water* flow change?
**Resolution**: There was general agreement to this wording change.

## 5. Conservation Element Selection

### 5.1 Introduction

REAs are intended to characterize the current status (baseline conditions) and forecast the future condition of ecological resources in the Sonoran Desert. This process requires identification of a set of conservation elements that can provide a picture of the general condition of the resources of conservation concern within the region. The REA Task Order defines core conservation elements as biotic constituents (wildlife and plant species and assemblages) or abiotic factors (e.g., soils, regional values) of regional significance in major ecosystems and habitats across the level III ecoregion. A limited suite of conservation elements is designed to represent the entirety of renewable resources and values within the ecoregion; as such, it is suggested that the individual conservation elements may serve as surrogates for ecological integrity across the ecoregion. However, in the Statement of Work (SOW), REAs are also defined as “assessments only, evaluating status and potential changes in status for selected core conservation elements.” Development of landscape-level indicators of biological or ecological integrity that are based on empirically-derived responses of conservation elements to disturbance are beyond the scope of the REA process since this would require a major research effort. For the purposes of the REAs, BLM and agency partners are currently developing an approach to characterize landscape-level ecological integrity or condition based on existing geospatial data. Dynamac proposes using landscape condition estimates, including the condition of landscapes and habitats of a selected suite of species as indicators of the condition of the ecoregion. These estimates will be based primarily on measures of direct anthropogenic disturbance and inferred qualitative levels of stress on the suite of species selected. These assessments, taken collectively, will provide a basis for comparing current and inferred future status within ecoregions.

A number of strategies have been devised to conduct assessments of ecological condition, from rigorous, scientifically-defensible indices of biological integrity or IBIs, to more qualitative, conservation guidance approaches such as those discussed by Parrish *et al*. (2003) and Unnasch *et al*. (2008). Approaches such as these differ in rigor and defensibility, and they also differ in terms of their potential application for programs such as Rapid Ecoregional Assessments. Indices of biotic integrity (IBIs), developed for aquatic ecosystems, use systematically-collected species abundance data to develop metrics representing taxonomic richness, trophic categories, or sensitivity to disturbance. Metrics are screened for responsiveness to disturbance, low variability, and lack of redundancy (Hughes et al. 1998, Mebane et al. 2003, Whittier et al. 2007).

The development of indicators of physico-chemical and biotic conditions is grounded in the establishment of a human disturbance gradient (Figure 5). Minimally- or least-disturbed sites serve as a reference model against which to compare the condition of disturbed sites. A collection of reference sites represents the range of natural variability in undisturbed sites that allows the recognition and separation of natural from anthropogenic disturbances at sites influenced by human activities (Hughes et al. 1986, Hughes 1995, Lattin *et al*. In Review, Whittier et al. 2007), Once natural variability has been documented, the remaining stressor signal associated with anthropogenic disturbances is used to empirically define departure from the reference or least-disturbed condition.

Few indices of *terrestrial* ecological integrity have been developed using the approach described above. Terrestrial indices present even greater challenges than aquatic indices of biointegrity, and terrestrial applications of indices of biotic integrity are limited in the scientific literature (O'Connell et al. 1998, Bradford et al. 1998, Cully and Winter 2000, Bryce et al 2002, Bryce 2006, Mattson and Angermeier 2007).

For the REAs, the Dynamac team will develop an analog to the IBI approach to assess the condition of conservation elements against an operationally defined reference condition based on best professional judgment. We will measure the relative departure in condition away from the reference condition as a qualitative measure of resource status. Each conservation element will be considered a metric of ecological condition. For each metric, we will develop a set of operational definitions of ranges of departures from reference condition, classified as least-disturbed condition, moderately-disturbed condition, and most-disturbed condition. We will attempt to base these classes on threshold percentiles of reference condition. Where this is not feasible, we will establish clear, easily repeatable operational definitions of these classes using best professional judgment. Ecological condition within landscape reporting units and within the ecoregion will be based on the percent of metrics that are judged to be within the range of least-disturbed condition, the percent of metrics that are judged to be within the range of moderately-disturbed condition, and the percent judged to be within the range of most-disturbed condition. We will summarize relative condition within each landscape reporting unit using an approach comparable to calculating relative risk (RR) in the biological assessment approach (Mattson and Angermeier 2007).

## 5.2 Conservation Elements

### 5.2.1 Coarse-filter Ecological Systems

#### 5.2.1.1 Introduction

Condition assessments within the REA framework were intended to follow the coarse-filter/fine-filter approach. As discussed in the introductory section, the fine-filter component was modified by the AMT after considering the results of our preliminary tests. The coarse-filter component remains the foundation of the REA assessment process, with its conservation elements representing characteristic vegetation assemblages occurring within the ecoregion. Dynamac will characterize the vegetation assemblages' current distribution and vulnerability to change agents, including predicted vulnerability associated with climate change.

#### 5.2.1.2 Selection Approach

We have elected to base the coarse-filter Ecological Systems on the vegetation types defined in the SWReGAP project (Figure 6, Prior-Magee et al. 2007). This classification approach will provide the necessary detail to characterize habitat occupancy for the landscape-species conservation elements that will be used as substitutes for fine-filters in this REA. We elected to include all Ecological Systems present in the ecoregion to serve as coarse filters, rather than just those occupying a large fraction of the landscape, since some of the smaller vegetation classes have importance as habitat disproportionate to their area (Appendix 1).

### 5.2.2 Fine-Filter Plant Species Conservation Elements

#### 5.2.2.1 Introduction

Dynamac was directed by the AMT to identify a dominant plant species associated with each of the principle Ecological Systems in the Sonoran Desert. These plant species, although they occur in other Ecological Systems in the ecoregion, will represent fine-filter species for the purpose of this REA. Dynamac will characterize their current distribution and vulnerability to change agents, including predicted vulnerability associated with climate change.

#### 5.2.2.2 Selection Approach

We reviewed the descriptions of the Ecological Systems in the SWReGAP program (Prior-Magee et al. 2007). We identified dominant overstory species and selected a single species from each Ecological System. Two species were selected for two Ecological Systems representing 75.8% of the landscape in the Sonoran Desert ecoregion (Table 1).

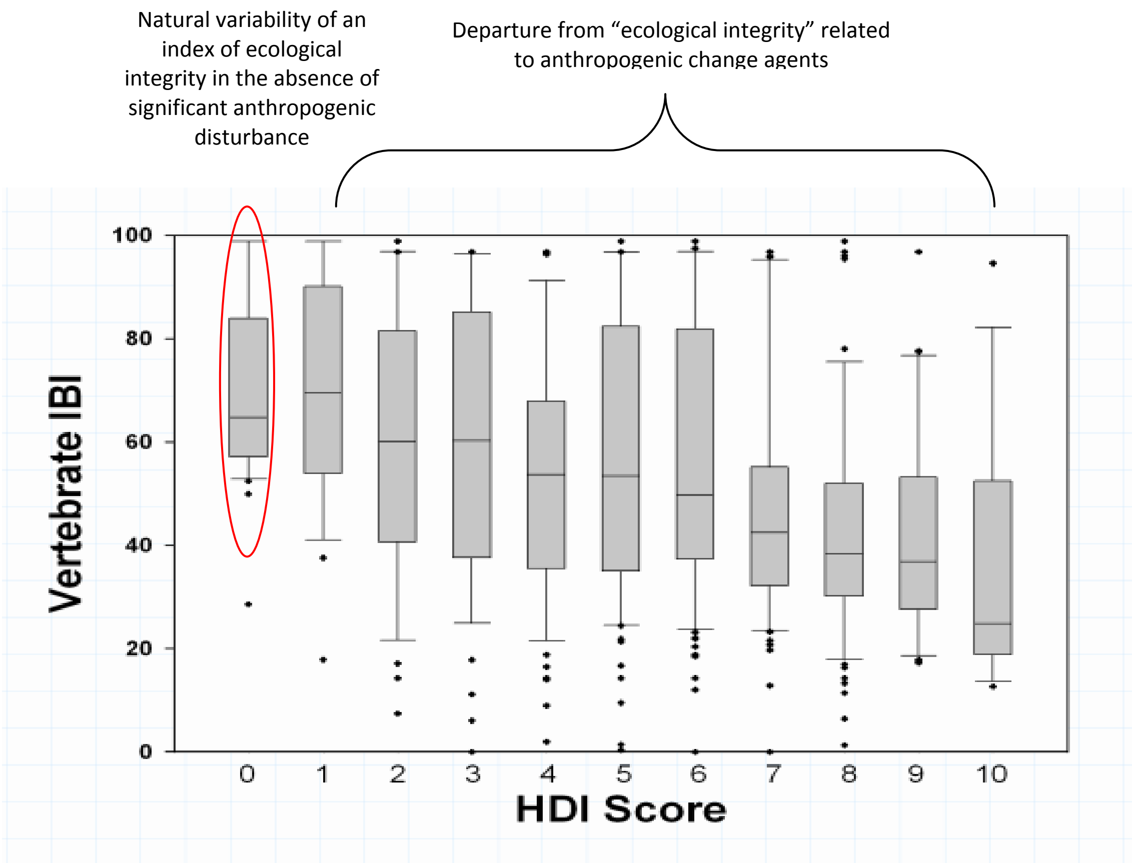


**Figure 5. An example of an indicator of ecological integrity (Vertebrate Index of Biotic Integrity or IBI) plotted against a watershed-level human disturbance gradient (Human Disturbance Index or HDI). Variability associated with no detected disturbance (HDI = 0) is representative of variability in a measure of ecological integrity under reference (least-disturbed) conditions. The range of scores associated with HDI values of 1 or more represent a departure from an empirically-derived characterization of ecological integrity. The field sampling, analyses, and calibration of the IBI required more than 5 years and $10,000,000 to develop. By comparison, the development and implementation of the remotely-sensed disturbance index (HDI) required 3 months and less than $10,000. (Lattin *et al*. In Review)**

### 5.2.3 Landscape-Species Conservation Elements

#### 5.2.3.1 Introduction

The landscape species approach to conservation element selection is roughly analogous to selection of principle components in principle components analysis (PCA). Species are selected that capture a range of important attributes characterizing the environment in which they occur. These include habitat use heterogeneity, large area requirements, vulnerability to anthropogenic disturbance or threats associated with change agents, functional contributions to the ecological system, and relative socio-economic importance (Coppolillo *et al*. 2004). Species are ranked in descending order of aggregate scores for each of these attributes and selected based on both aggregate score and the ecological systems they use. Each subsequent species is selected on the basis of score and minimum overlap in ecological systems used, until all ecological systems are accounted for. A cross check is then made to ensure that all change agent threats are accounted for as well. The final number of species is expected to be within 4–6, from an original, somewhat arbitrary, selection of candidate 10–25 species. The AMT requested that we also include the core desired species that they identified in the list of candidate species.

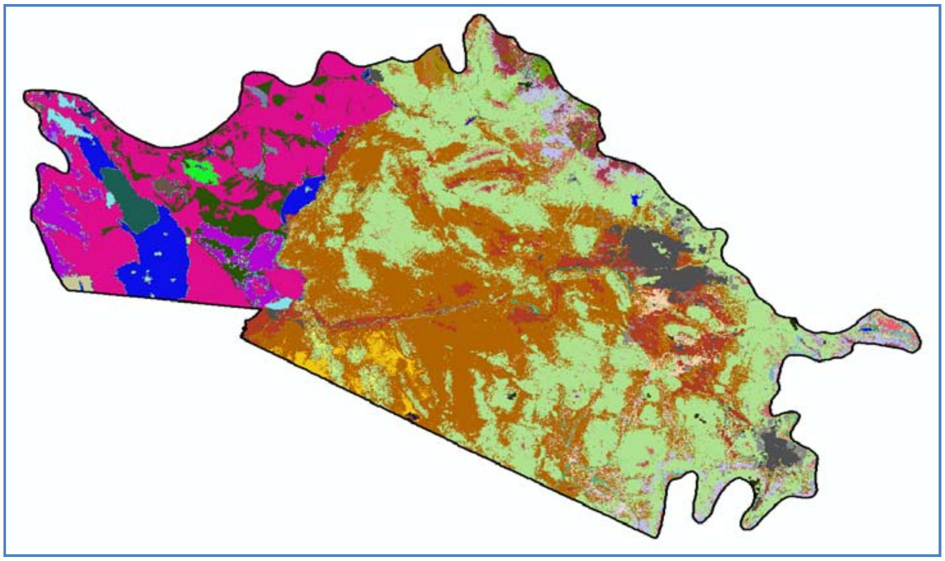

**Figure 6. Preliminary distribution of coarse-filter Ecological Systems in the Sonoran Desert ecoregion. Note the differences in classifications between the California and Arizona portions of the ecoregion, which will require standardization. (SWReGAP and California GAP data).**

**Table 1. Selected plant species (fine-filters) representative of principle Ecological Systems in the Sonoran Desert ecoregion.**

| ECOLOGICAL SYSTEM | % OF ECOREGIO N | SPECIES (Common Name) | SCIENTIFIC NAME |
|---|---|---|---|
| Sonoran Paloverde-Mixed Cacti Desert Scrub | 33.5% | Saguaro | *Carnegia gigantean* |
| Sonora-Mojave Creosotebush-White Bursage Desert Scrub | 42.3% | Creosotebush | *Larrea tridentata* |
| TOTAL AREA | 75.8% | | |

### 5.2.3.2 Selection Approach

It became apparent that there was insufficient time to obtain all of the information required to apply the Coppolillo *et al*. approach as defined. We submitted a request to the BLM Point of Contact for future access to a compiled database containing enough of the needed information to select species using the Coppolillo approach in future REAs. For this REA, we adapted the Coppolillo approach to be applicable within the time limitations following the first workshop feedback.

Selection of landscape species is considered a structured and transparent, albeit somewhat arbitrary, approach to the identification of a suite of species for the assessment of ecoregional condition. The authors acknowledge that validation of this approach, or any coarse-filter approach, has not been performed, and suggest that such validation my not even be possible. As designed however, the method can be valuable for guiding conservation efforts. Its ultimate utility, however, depends on whether the results of the evaluations of condition for a collection of species can help inform the development of management plans.

For the purposes of the REA analyses, we propose the following operational definitions:

*Habitat heterogeneity:* The number of natural major ecological systems within the ecoregion that the species is known to use (SWReGAP Habitat Relationship Reports), divided by the total number of ecological systems in the ecoregion and scaled between 0–1, with higher values representing greater utility as a landscape species for the REA (Prior-Magee et al. 2007).

*Area requirements:* A binned estimate of the approximate home-range (NatureServe) size class, scaled between 0–1 (< 1km$^2$ = 0, 1 – 10km$^2$ = 0.25, 10 – 25km$^2$ = 0.5, 25 – 50km$^2$ = 0.75, >50km$^2$ = 1) as recommended by Coppolillo *et al*. (2004). A binned estimate (based on SWReGAP species distribution maps) of the approximate proportion of the ecoregion used by the species (<5% = 0, 5 – 10% = 0.25, 10 – 25% = 0.5, 25 – 50% = 0.75, >50% = 1). These two measures will be summed and divided by 2 to normalize the area-requirement metric.

*Vulnerability to anthropogenic disturbance:* We based the vulnerability criterion on a reclassification of the Global and State ranking systems (NatureServe). A rounded G-rank of G5 (or T5) was assigned “0”, G4 (or T4) was assigned “0.25”, G3(or T3) was assigned “0.5”, G2 (or T2) assigned “0.75”, and G1(or T1) assigned “1”. State ranks were averaged and assigned scores in the same way. The vulnerability score was based on the higher of the G-rank (T-rank) and S-rank for each candidate species. The vulnerability scores were intended to reflect the status of the species within the ecoregion, from secure (0), apparently secure (0.25), vulnerable (0.5), imperiled (0.75), or critically imperiled (1.0).

*Functionality:* Functions are defined as (1) predation, (2) prey base, (3) seed dispersal, (4) seed predation, (5) pollination, (6) mechanical disturbance, and (7) strong competitive interactions. Species lacking a strong role for a specific function are assigned a 0; those with a clear role received a score of 1, based on best professional judgment. The function scores are summed and then divided by the maximum number of functions a species on the list received to normalize the functional score.

*Socio-economic significance*: The score is based on the sum of following binary characteristics: (1) a flagship species, (2) has a positive social value, (3) has a negative social value, (4) has a positive economic value, and (5) has a negative economic value, based on best professional judgment. The score ranges from 0–1, with 0 having little or no socio-economic value, and 1 having considerable socioeconomic value, scored thus: 0 = 0, 1 = 0.33, 2 = 0.66, and 3+ = 1.

The five categories of scores are summed and defined as the landscape species Aggregate Score. Species with the highest scores were considered most suitable for consideration among the suite of landscape species.

The final selection of species was based on both the aggregate score and the types of the Ecological Systems used, as noted above. The species with the highest aggregate score was selected first, followed by the species with the next highest score, which also had the least overlap in Ecological Systems (coarse filter vegetation communities) used. The process continued until all of the Ecological Systems were accounted for among the suite of selected landscape species. Coppolillo *et al*. (2004) suggest that we begin with 10–25 species and ultimately select 4–6 landscape species. In our approach, we began with 25–30 species, with the intent to select no more than 10. Our candidate species were drawn from the species lists in the State Wildlife Action Plans and from the list of modeled vertebrates in the SWReGAP final report (Prior-Magee et al. 2007).

We found that this approach was not very suitable for the selection of aquatic species, unless they were treated separately. We opted to simplify the process and hand select likely vulnerable candidates representing the major types of aquatic ecological systems in the ecoregion. In addition, we found that riparian areas were not well represented in the final suite of selected species. We then selected a riparian obligate with the widest distribution and highest aggregate score and added it to the suite of landscape species.

#### 5.2.3.3 Final Landscape-species Conservation Element Selections

The list of candidate species selected for evaluation, and their scores are shown in Appendix (2). The species selected for the final suite of landscape species are shown in Table 2. At the direction of the AMT, the Burrowing owl was substituted for the Peregrine falcon. To account for Ecological Systems which remained following substitution of the Burrowing owl for the Peregrine falcon, we added the Mule deer. We elected not to include the bobcat, which would have filled the needed Ecological Systems, since we had already selected a large carnivore. To make sure that we included a riparian obligate, we added the Lucy’s warbler. The Gila topminnow was selected to capture streams, springs, and shallow backwaters of larger bodies of water, while the razorback sucker was chosen as representative of medium and larger rivers and their impoundments. The effect of cumulative additions of landscape species candidates on the number of ecological systems and threats accounted for is illustrated in Figure 7. Addition of each new species is based on the aggregate score and the degree of overlap in terms of associated Ecological Systems with the previously accepted species.

### 5.2.4 Desired Species Conservation Elements

#### 5.2.4.1 Introduction

A list of desired species conservation elements was provided by the AMT in the Statement of Work for this REA. We included these species as candidates in the landscape species selection process. If an AMT species was not selected for the limited suite of landscape species conservation elements, it was reassigned as a “desired” species conservation element. These elements will be treated and reported on separately in the REA final report summaries.

**Table 2. Category and aggregate scores for selected Sonoran landscape species.**

| SPECIES | AREA | HETEROGENEITY | VULNERABILITY | FUNCTIONALITY | SOCIO-ECONOMIC SIGNIFICANCE | SPECIES SCORE |
|---|---|---|---|---|---|---|
| Mountain lion | 1.00 | 0.84 | 0.25 | 0.50 | 0.80 | 3.39 |
| Burrowing owl | 0.63 | 0.39 | 0.50 | 1.00 | 0.40 | 2.91 |
| Kit fox | 0.75 | 0.55 | 0.25 | 1.00 | 0.20 | 2.75 |
| Mule deer | 0.63 | 1.00 | 0.00 | 0.50 | 0.40 | 2.53 |
| Desert bighorn sheep | 0.38 | 0.48 | 0.50 | 0.50 | 0.60 | 2.46 |
| Lucy's warbler | 0.38 | 0.39 | 0.50 | 0.00 | 0.20 | 1.46 |
| Gila topminnow | 0.00 | 0.00 | 0.75 | 0.00 | 0.40 | 1.15 |
| Razorback sucker | 0.00 | 0.00 | 1.00 | 0.00 | 0.60 | 1.60 |

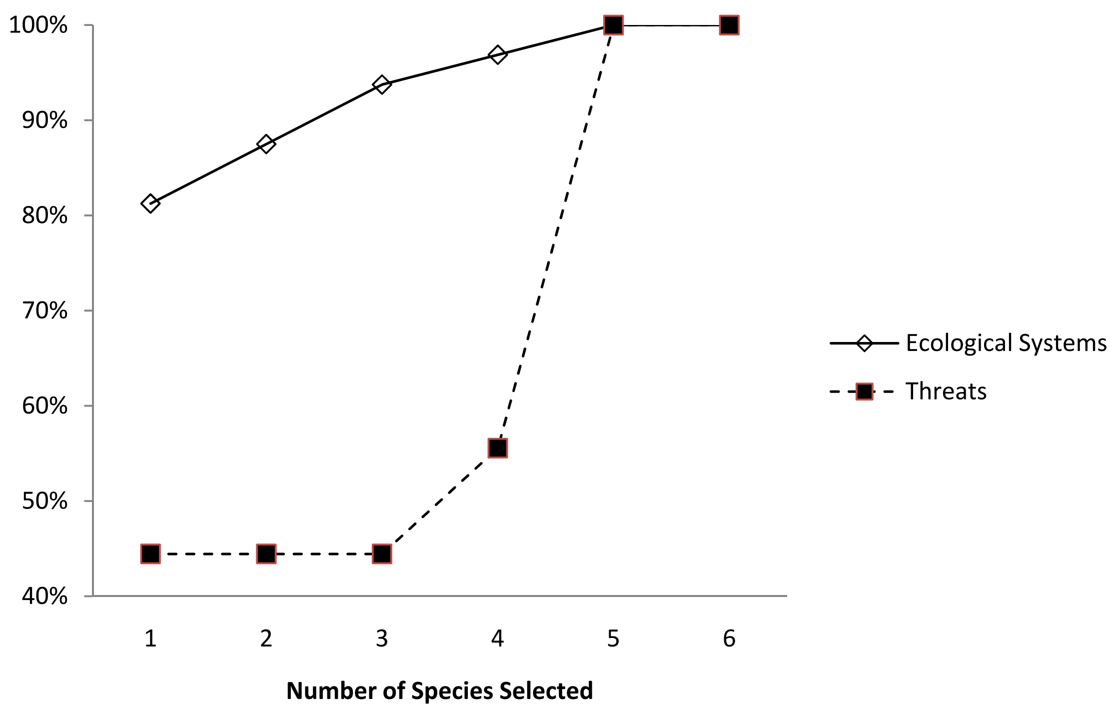


**Figure 7. Cumulative numbers of Ecological Systems required and major threats encountered by the selected suite of terrestrial landscape species (Y-axis) as species were added to the suite (X-axis) for the Sonoran Desert. After Coppollilo, 2003.**

### 5.2.4.2 Final Desired Species Conservation Element Selections

The species which will be treated as desired species conservation elements in this REA are shown in Table 3:

**Table 3. Desired Species Conservation Elements for the Sonoran Desert Ecoregion tested using a modified version of the Coppolillo *et al*. (2004) approach (see text for details).**

| SPECIES | AREA | HETEROGENEITY | VULNERABILITY | FUNCTIONALITY | SOCIO-ECONOMIC SIGNIFICANCE | SPECIES SCORE |
|---|---|---|---|---|---|---|
| Desert tortoise – Sonoran Population | 0.63 | 0.19 | 0.25 | 0.50 | 0.40 | 1.97 |
| Desert tortoise- Mohave Population | 0.63 | 0.19 | 0.75 | 0.50 | 0.40 | 2.47 |

## 5.2.5 Sites of Conservation Concern as Conservation Elements

### 5.2.5.1 Introduction

Vegetation, terrestrial, and aquatic species can move through space and time in response to agents of change, including climate change. Terrestrial and aquatic sites of conservation concern cannot; therefore, they represent a particular challenge for management planning, and must be managed *in situ*. In all likelihood, many sites will lose the functionality for which they were designated as a result of interactions between climate change and other change agents such as fire and invasive species. In this REA, we will assess current and forecasted threats to a defined set of sites from a range of agents of change.

### 5.2.5.2 Final Sites of Conservation Concern Selections

The Dynamac team suggested that the AMT consider adding an additional biodiversity indicator. We proposed that we summarize all available location data of species of concern (Federally Listed T, E, candidate species, and State Ranked G1–G3 species in a couple of ways: by occurrence at the 5$^{th}$ level HUC landscape reporting unit and within a coarse grid with a resolution of 50x50 km. We would summarize this generalized diversity of species of conservation concern within various landscape reporting units (5$^{th}$ level HUCs and Level IV ecoregions). We intend to ensure that species are drawn from State Wildlife Action Plans and occur in at least 5% of the ecoregion in this evaluation to capture a different picture of species richness at the ecoregion scale.
**Resolution:** The AMT accepted this additional biodiversity conservation element and recommended that we complete one or two CEs (plant and animal) for this modeling exercise.

**Table 4. Sites of Conservation Concern Conservation Elements selected for the Sonoran Desert Ecoregion**.

| SITE CLASSES | RESOLUTION |
|---|---|
| **Terrestrial Sites of High Biodiversity:** | |
| TNC portfolio sites | ACCEPTED |
| NatureServe/Natural Heritage sites | ACCEPTED |
| Important bird areas (Audubon) | ACCEPTED |
| Areas recognized by Partners-In-Flight | ACCEPTED |
| Areas recognized by State Wildlife Action Plans | ACCEPTED |
| **Terrestrial Sites of High Ecological and/or Cultural Value:** | |
| Wilderness Areas | ACCEPTED |
| Wilderness Study Areas | ACCEPTED |
| National Wildlife Refuges | ACCEPTED |
| Monuments | ACCEPTED |
| National and State Parks | ACCEPTED |
| NCAs | ACCEPTED |
| ACECs | ACCEPTED |
| State Wildlife Management Areas | ACCEPTED |
| Suitable Wild and Scenic Rivers | ACCEPTED |
| Designated Recreation Management Areas | ACCEPTED |
| Large Conservation/Reserved Areas (e.g., CRP, conservation easements): | ACCEPTED |
| Visual Resource Management | ACCEPTED |
| **Aquatic Sites of High Biodiversity:** | |
| TNC portfolio sites | ACCEPTED |
| NatureServe/Natural Heritage sites | ACCEPTED |
| Areas recognized by State Wildlife Action Plans | ACCEPTED |

### 5.2.6 Ecosystem Functions and Services as Conservation Elements

#### 5.2.6.1 Final Functions and Services of Conservation Concern Selections

**Table 5. Functions and Services of Conservation Concern as Conservation Elements selected for the Sonoran Desert Ecoregion**

| SITE CLASSES | RESOLUTION |
|---|---|
| **Surface and Subsurface Water Availability:** | |
| Aquatic systems of streams, lakes, ponds, etc. | ACCEPTED |
| Gila River | ACCEPTED |
| Bill Williams | ACCEPTED |
| Colorado River | ACCEPTED |
| Springs/seeps/wetlands | ACCEPTED |
| Riparian areas | ACCEPTED |
| Saline | ACCEPTED |
| High quality and impaired waters | ACCEPTED |
| Man-made water sources | AMT proposed ACCEPTED |
| Groundwater protection zones, sole source aquifers | ACCEPTED |
| Wildlife water developments and Range improvements | ACCEPTED |

## 6. Change Agents

### 6.1 Introduction

The purpose of the REA is to assess the current condition of ecoregional natural resources, and to predict future condition at several time horizons. Condition or status of resources will be assessed with respect to threats posed by anthropogenic disturbances or change agents. Natural disturbance agents and cycles influence population dynamics and the status of species as an assumed backdrop to stresses imposed by anthropogenic disturbance. We have broken down these threats into general categories, including upland habitat loss (semi-permanent and permanent), riparian habitat loss, aquatic habitat loss, terrestrial habitat fragmentation, aquatic habitat fragmentation, upland habitat disturbance (transient habitat loss, stresses), riparian habitat disturbance, aquatic habitat disturbance, direct take, bioaccumulation of toxins. We chose to characterize threats first, and then assign change agents to the threat categories. The specific change agents responsible are less important than understanding the threats that they pose to the condition of vulnerable resources. The same change agent may represent a threat to one organism and a benefit to another. We have identified a set of key change agents that represent a threat to vulnerable resources in this ecoregion. The general relationship between change agents and the types of threats that they can represent to conservation elements are illustrated in Appendix 3. We have included those change agents identified by the AMT in the Statement of Work, as well as an additional change agent that was recommended and has been accepted following AMT review.

### 6.2 Final Selection of Change Agents

**Table 6. Change Agents selected for the Sonoran Desert Ecoregion.**

| CHANGE AGENTS | RESOLUTION |
|---|---|
| Wildland Fire | |
| Invasive Species | ACCEPTED |
| Land and Resource Use | ACCEPTED |
| Urban and Roads Development | |
| Oil, Gas, and Mining Development | |
| Renewable Energy Development (i.e., solar, wind, geothermal, including transmission corridors) | |
| Agriculture | ASSUMED by Dynamac |
| Livestock grazing (proposed by Dynamac) | **Resolution:** The grazing issue will require further discussion by the AMT and the Washington office; they will specify how it should be addressed. The AMT will compile questions referring to grazing as a change agent. |
| Groundwater Extraction and Transportation | ACCEPTED |
| Recreational Uses | ACCEPTED |
| Pollution (Air Quality) | ACCEPTED |
| Climate change | ACCEPTED |

## 7. REA Output Products

The REA process is to develop a comprehensive picture of the current status and projected changes of important ecological resources, functions, and services during the next 50 years. The final products of this process will be prepared to be relevant to future analyses of Cumulative Impacts (NEPA) and Currently Affected Environment for RMPs. Several different approaches will be used in concert to characterize potential changes to these key ecological resources under near-term and long-term time scenarios. These projections will be prepared to inform decisions on proposed land use allocations and the potential cumulative impacts associated with these proposed allocations. One additional objective is to help identify both on- and off-site opportunities for mitigating potential impacts of land use allocation changes.

REA output products are the primary outputs of ecoregional analysis; they are used to summarize landscape status and potential for change for tabulation and display. Output products may be generated for any specific conservation element or change agent. Output products for specific conservation elements and change agents will be characterized in two categories: status products and potential for change products.

### STATUS PRODUCTS

- Status is characterized by attributes and indicators for:
  - Size (e.g., magnitude, proportion, density),
  - Condition (i.e., quality),
  - Landscape Context (i.e., relationship to surrounding landscape), and
  - Trend (i.e., current change with no additional [i.e., future] change agent forcing.)

### POTENTIAL FOR CHANGE PRODUCTS

- Potential for change is characterized by attributes and indicators for:
  - Direction of change (i.e., increasing/decreasing),
  - Magnitude or scope of change,
  - Likelihood of change, and
  - Certainty of change.

### REPORTING UNITS OF MEASURE

Categorical information depicting attributes is used to tabulate and display REA output products. Although actual numerical measurements and/or model outputs may be available for some conservation elements/change agents, thresholds are set to categorize all data into standard reporting categories. During review of the Draft Memorandum, a comment was made regarding units of measure. There was concern that the labels might be misleading, and that a clear understanding is needed for the condition status as related to the each conservation element. This was a very good point, and it relates back to the discussion of development of indicators of biological integrity (Section 4.1). It will be extremely important to base condition of conservation elements on a standardized measure away from some point of reference. No two organisms respond in the same way to a specific disturbance or stress.

- Categorical information is the primary information type tabulated and displayed (on maps) for the output products of ecological integrity, status, and potential for change.
- Categories are established by setting thresholds delineating the acceptable range of variation for attributes/indicators.
- Descriptive attribute/indicator categories include (but are not limited to):
  - Poor – Fair – Good – Very Good – Unknown – None/NA
  - Low/none – Moderate – High – Very High – Unknown
  - Present – Absent – Unknown

The descriptive categories are intended to facilitate presentation of complex findings in a simplified manner. Operational definitions for categories will be provided to aid in interpretation and future comparisons.

## 8. SUMMARY

During the first stage of this REA, our objective was to characterize the major ecological components of the ecoregion, the threats or stressors to those components, and the change agents responsible for those threats or stresses. We constructed a simplified model of the general relationships between these elements, reviewed the management questions provided by the AMT, revised or suggested additional questions, identified the important agents of change within the ecoregion, and selected a suite of conservation elements upon which to base our assessment of natural resource conditions within the ecoregion. We identified a set of coarse-filter Ecological Systems to be assessed, a set of plant species associated with the dominant Ecological Systems, and a set of landscape species to assess condition of the landscape with respect to specific habitat and life history needs of multiple species. Some conservation elements must be managed in place, such as sites of ecological value. We identified a suite of sites to evaluate. Many of these will likely lose the reason for their establishment as a result of disturbance associated with climate change. We also selected a set of desired species identified by the AMT that did not make it on to the landscape species list through the sorting process. These will be evaluated in a separate set of assessments. Lastly, we identified a set of major agents of change which represent a range of threats to resources of conservation concern. The final selection represents a constructive and iterative process involving AMT guidance, clarifications, feedback at the first workshop, and peer review. Collectively, the assessments that will be conducted will provide a means to establish baseline condition for a suite of important resources in the Sonoran Desert ecoregion. This baseline condition will be used to characterize the potential trends in resource condition in the coming years, both in the near-term, as a consequence of development activities and the spread of invasive species, and in the long-term, as a result of climate change.

During this process, we have provided BLM with feedback regarding approaches, time and level of effort constraints, and other conceptual matters that form the basis of the REA process. We hope that this feedback will be helpful during the development and refinement of future statements of work for future REAs in the coming years.

## Literature Cited


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# APPENDIX 1. Coarse-Filter Ecological System Selections

| FOREST AND WOODLAND CLASSES (1.0%) | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 0.06% | S035 | Madrean Pine-Oak Forest and Woodland |
| 0.00% | S036 | Rocky Mountain Ponderosa Pine Woodland |
| 0.17% | S039 | Colorado Plateau Pinyon-Juniper Woodland |
| 0.15% | S040 | Great Basin Pinyon-Juniper Woodland |
| 0.07% | S051 | Madrean Encinal |
| 0.56% | S112 | Madrean Pinyon-Juniper Woodland |

| SHRUB /SCRUB CLASSES (82.4%) | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 1.21% | S057 | Mogollon Chaparral |
| 2.13% | S058 | Apacherian-Chihuahuan Mesquite Upland Scrub |
| 0.34% | S060 | Mojave Mid-Elevation Mixed Desert Scrub (*including the Joshua Tree anomaly*) |
| 0.01% | S061 | Chihuahuan Succulent Desert Scrub |
| 0.25% | S062 | Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub |
| 33.48% | S063 | Sonoran Paloverde-Mixed Cacti Desert Scrub (*including Saguaro communities*) |
| 0.01% | S068 | Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub |
| 42.36% | S069 | Sonora-Mojave Creosotebush-White Bursage Desert Scrub |
| 0.97% | S070 | Sonora-Mojave Mixed Salt Desert Scrub |
| 0.22% | S116 | Chihuahuan Mixed Salt Desert Scrub |
| 1.46% | S129 | Sonoran Mid-Elevation Desert Scrub |

| GRASSLAND / HERBACEOUS CLASSES (0.5%) | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 0.20% | S075 | Inter-Mountain Basins Juniper Savanna |
| 0.25% | S077 | Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe |
| 0.00% | S113 | Chihuahuan Sandy Plains Semi-Desert Grassland |
| 0.03% | S115 | Madrean Juniper Savanna |

**Coarse Filter Ecological System Conservation Elements for the Sonoran Desert ecoregion. (continued…)**

| **WOODY WETLAND / RIPARIAN CLASSES (3.4%)** | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 2.77% | S020 | North American Warm Desert Wash |
| 0.01% | S094 | North American Warm Desert Lower Montane Riparian Woodland and Shrubland |
| 0.18% | S097 | North American Warm Desert Riparian Woodland and Shrubland |
| 0.49% | S098 | North American Warm Desert Riparian Mesquite Bosque |

| **EMERGENT HERBACEOUS WETLAND CLASSES (0.0%)** | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 0.00% | S100 | North American Arid West Emergent Marsh |

| **SPARSELY VEGETATED / BARREN CLASSES (1.7%)** | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 0.00% | S010 | Colorado Plateau Mixed Bedrock Canyon and Tableland |
| 0.13% | S016 | North American Warm Desert Bedrock Cliff and Outcrop |
| 0.89% | S018 | North American Warm Desert Active and Stabilized Dune |
| 0.02% | S019 | North American Warm Desert Volcanic Rockland |
| 0.67% | N31 | Barren Lands, Non-specific |

| **OPEN WATER (1.1%)** | | |
|---|---|---|
| Percent of ecoregion | Code | Ecological System |
| 1.05% | N11 | Open Water |

Classes adapted from:

Lowry, J. H, Jr., R. D. Ramsey, K. Boykin, D. Bradford, P. Comer, S. Falzarano, W. Kepner, J. Kirby, L. Langs, J. Prior-Magee, G. Manis, L. O'Brien, T. Sajwaj, K. A. Thomas, W. Rieth, S. Schrader, D. Schrupp, K. Schulz, B. Thompson, C. Velasquez, C. Wallace, E. Waller and B. Wolk. 2005. *Southwest Regional Gap Analysis Project: Final Report on Land Cover Mapping Methods*, RS/GIS Laboratory, Utah State University, Logan, Utah.

# APPENDIX 2. Candidate Landscape Species Selections and Scores

| SPECIES | SCEINTIFIC NAME | AREA | HETEROGENEITY | VULNERABILITY | FUNCTIONALITY | SOCIO-ECONOMIC SIGNIFICANCE | SPECIES SCORE |
|---|---|---|---|---|---|---|---|
| Mountain lion | *Puma concolor* | 1.00 | 0.84 | 0.25 | 0.50 | 0.80 | 3.39 |
| American Peregrine Falcon | *Falco peregrinus* | 1.00 | 0.74 | 0.50 | 0.50 | 0.20 | 2.94 |
| Burrowing owl | *Athene cunicularia* | 0.63 | 0.39 | 0.50 | 1.00 | 0.40 | 2.91 |
| Peninsular Bighorn | *Ovis canadensis pop. 2* | 0.38 | 0.10 | 1.00 | 0.50 | 0.80 | 2.77 |
| Mexican long-tongued bat | *Choeronycteris mexicana* | 0.13 | 0.29 | 0.75 | 1.00 | 0.60 | 2.77 |
| Kit fox | *Vulpes macrotis* | 0.75 | 0.55 | 0.25 | 1.00 | 0.20 | 2.75 |
| Bobcat | *Lynx rufus* | 0.88 | 0.68 | 0.00 | 0.50 | 0.60 | 2.65 |
| Big free-tailed bat | *Nyctinomops macrotis* | 1.00 | 0.94 | 0.50 | 0.00 | 0.20 | 2.64 |
| Mule deer | *Odocoileus hemionus* | 0.63 | 1.00 | 0.00 | 0.50 | 0.40 | 2.53 |
| Desert tortoise – Mohave Population | *Gopherus agassizii pop. 1* | 0.63 | 0.19 | 0.75 | 0.50 | 0.40 | 2.47 |
| Desert bighorn (not Peninsular) | *Ovis Canadensis nelsoni* | 0.38 | 0.48 | 0.50 | 0.50 | 0.60 | 2.46 |
| Cactus ferruginous pygmy-owl | *Glaucidium brasilianum cactorum* | 0.38 | 0.16 | 1.00 | 0.50 | 0.40 | 2.44 |
| Lesser Long-nosed bat | *Leptonycteris yerbabuenae* | 0.88 | 0.19 | 0.75 | 0.00 | 0.40 | 2.22 |
| Antelope jackrabbit | *Lepus alleni* | 0.50 | 0.29 | 0.50 | 0.50 | 0.20 | 1.99 |
| Desert tortoise – Sonoran Population | *Gopherus agassizii pop. 2* | 0.63 | 0.19 | 0.25 | 0.50 | 0.40 | 1.97 |
| Gilded Flicker | *Colaptes chrysoides* | 0.38 | 0.23 | 0.25 | 0.50 | 0.40 | 1.75 |
| Southwestern Willow Flycatcher | *Empidonax traillii extimus* | 0.00 | 0.13 | 1.00 | 0.00 | 0.60 | 1.73 |
| Desert pupfish | *Cyprinodon macularius* | 0.00 | 0.00 | 1.00 | 0.00 | 0.60 | 1.60 |
| Razorback sucker | *Xyrauchen texanus* | 0.00 | 0.00 | 1.00 | 0.00 | 0.60 | 1.60 |
| Flat-tailed horned lizard | *Phrynosoma mcallii* | 0.25 | 0.06 | 0.75 | 0.00 | 0.40 | 1.46 |
| Lucy's warbler | *Vermivora luciae* | 0.38 | 0.39 | 0.50 | 0.00 | 0.20 | 1.46 |
| Sage thrasher | *Oreoscoptes montanus* | 0.50 | 0.52 | 0.00 | 0.00 | 0.20 | 1.22 |
| Gila topminnow | *Poeciliopsis occidentalis* | 0.00 | 0.00 | 0.75 | 0.00 | 0.40 | 1.15 |
| Lowland leopard frog | *Rana yavapaiensis* | 0.38 | 0.00 | 0.25 | 0.00 | 0.20 | 0.83 |
| Arizona toad | *Bufo microscaphus* | 0.00 | 0.10 | 0.50 | 0.00 | 0.20 | 0.80 |
| Canyon treefrog | *Hyla arenicolor* | 0.38 | 0.00 | 0.00 | 0.00 | 0.20 | 0.58 |

# APPENDIX 3. The Relationship Between Threats (Stressors) and Change Agents

| THREATS | CHANGE AGENTS |
|---|---|
| Upland habitat loss | Wildland fire (increased ignition frequency, increased severity, decreased frequency due to suppression), invasive species displacement of native vegetation (buffelgrass), land use change (urban, low-density residential, roads, infrastructure (e.g., powerlines), energy development, agriculture, overgrazing, etc. |
| Riparian habitat loss | Wildland fire, invasive species displacement of native vegetation(tamarisk), land use change (urban, low-density residential, roads, infrastructure (e.g., powerlines), energy development, agriculture, overgrazing, etc. |
| Aquatic habitat loss | Removal of riparian vegetation, channelization, water diversions, dams, water withdrawls, sedimentation, non-point source pollution, changes in flow, temperature, and sediment regimes, fragmentation of natural movements (culverts, low head dams), etc. |
| Terrestrial habitat fragmentation | Increased road density, agriculture, development, OHV use, logging, chaining, unnatural changes in characteristic disturbance regimes through fire suppression, increased fire frequency, … |
| Aquatic habitat fragmentation | Removal of riparian vegetation, channelization, water diversions, dams, water withdrawls, sedimentation, changes in flow, temperature, and sediment regimes, fragmentation of natural movements (culverts, low head dams), etc. |
| Upland habitat disturbance | Proximity to human infrastructure (urban, development, agriculture, roads, powerlines, etc.), and human land use activities (OHV use, livestock grazing, etc.), invasive species encroachment |
| Riparian habitat disturbance | Proximity to human infrastructure (urban, development, agriculture, roads, powerlines, etc.), and human land use activities (OHV use, livestock grazing, hunting, fishing, firewood removal, etc.), receipt of NPS pollution from activities associated with adjacent human-changed landcover/land use. |
| Aquatic habitat disturbance | Pollutants from human activities (point source & non-point source), changes in characteristic thermal, flow, sediment, O2, and sediment regimes. Boating, fishing, invasive aquatics (plant, animal) |
| Direct take | Hunting, fishing, trapping, poisoning, road kill, dam turbine kill, wind generator kill. |
| Bioaccumulation of toxins | Pollutants from a range of sources concentrating up trophic levels, causing mortality, reproductive failure, etc. |